2016 Biogenic Emission Inventory Collaborative

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\(^2\)United States Environmental Protection Agency (USEPA)
\(^3\)Georgia Department of Natural Resources (GADNR)
Biogenics Workgroup

- **Co-leads**: Jeff Vukovich (USEPA), Doug Boyer (TCEQ)
- **Schedule**: Calls on 3rd Tuesday at 2:00 pm Eastern
- **Wiki**: [http://views.cira.colostate.edu/wiki/wiki/9172](http://views.cira.colostate.edu/wiki/wiki/9172)
- Google drive: [https://drive.google.com/open?id=1ulLmJPQ1WkOnsi6_g2nkHLWfqJEw4RSU](https://drive.google.com/open?id=1ulLmJPQ1WkOnsi6_g2nkHLWfqJEw4RSU)
- Workgroup consists of one MJO (Western Regional Air Partnership) and state and local agencies (TCEQ, GADNR, California Air Resources Board, Maricopa and Pima Counties (Arizona), Alabama, Montana, New York)
2016 Biogenics Workgroup Charge

- Develop 2016 biogenic emission inventories (EIs) for photochemical model input for State Implementation Plans (SIPs) and other regulatory applications

- Document the EI development

- Compare the models’ output

- Conduct model performance evaluation
Biogenic Emission Models

- **Biogenic Emission Inventory System (BEIS)**
  - Version 3.61
  - EPA conducted annual 2016 simulation
  - Biogenic Emissions Landuse Database (BELD4.1) land use

- **Model of Emissions of Gases and Aerosols from Nature (MEGAN)**
  - Version 3.0 (released late 2017)
  - TCEQ conducted annual 2016 simulation
  - Database of growth forms and ecotypes
BEIS = Biogenic Emission Inventory System
FIA = USFS Forest Inventory and Analysis
MCIP = Meteorology-Chemistry Interface Processor
MODIS = Moderate Resolution Imaging Spectroradiometer
NLCD = National Land Cover Database
WRF = Weather Research and Forecasting Model

**Biogenic Emission Landuse Dataset (BELD) v4.1**

- % MODIS Land Use (Global)
- FIA V5.1 data
- % NLCD Canopy Coverage
- % NLCD Land Use (US)
- Allometric Scaling
- Spatial Kriging
- Model Ready Normalized Emissions for North America, 1km grid
- Tree Species Leaf Dry Mass
- Above Ground Biomass

**CMAS Center Spatial Allocator**

**BEIS v3.6.1**

- Model Domain BELD4 File
- Emissions Factors File for 286 categories (B360FAC)
- Speciation File for CB6 B10C6 (GSPRO)

**SMOKE v3.7+**

- Hourly resolved gridded biogenic emission estimates

**Flow Chart**

- WRF
- MCIP
- BIOSEASON

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**Notes:**

- BEIS = BEIS
- FIA = FIA
- MCIP = MCIP
- MODIS = MODIS
- NLCD = NLCD
- WRF = WRF

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**Abbreviations:**

- BEIS: Biogenic Emission Inventory System
- FIA: Forest Inventory and Analysis
- MCIP: Meteorology-Chemistry Interface Processor
- MODIS: Moderate Resolution Imaging Spectroradiometer
- NLCD: National Land Cover Database
- WRF: Weather Research and Forecasting Model

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**SMOKE v3.7+**

- Hourly resolved gridded biogenic emission estimates
MEGAN3 Flow Chart

**INPUT from Global Data Portal**
Download netcdf data
- Landcover
- LAI, Growth Form, Plant species composition, soil type
- Environmental conditions (hourly)
  - Temperature, light, wind, humidity, soil moisture, CO2, Ozone

**Preprocessor**
FORTRAN program regrids landcover and environmental conditions to time and spatial domain

**Canopy environment**
FORTRAN program calculates leaf light and temperature of shade and sun leaves at each canopy level

**Canopy emission activity**
FORTRAN program calculates emission response to canopy light, temperature, VOC, CO2, leaf age, LAI, Stress (extreme high or low temperature, high winds, ozone)

**Emission Factor Processor**
Python program calculates emission factors and light dependence factors

**Soil emission activity**
FORTRAN program calculates emission response to soil type, temperature, precipitation, soil moisture, fertilizer

**OUTPUT**
Time resolved gridded biogenic emissions

**Emission and chemical mechanism mapping**:
Calculate emissions and speciate to 200 individual compounds or species in selected chemical mechanism
BEIS or MEGAN?

Photochemical Modeling of the Ozark Isoprene Volcano: MEGAN, BEIS, and Their Impacts on Air Quality Predictions
Annmarie G. Carlton and Kirk R. Baker


A Tale of Two Models: A Comparison of the Biogenic Emission Inventory System (BEIS3.14) and Model of Emissions of Gases and Aerosols from Nature (MEGAN 2.04)

The Variability of Ozone Sensitivity to Anthropogenic Emissions with Biogenic Emissions Modeled by MEGAN and BEIS3
Eunhye Kim, Byeong-Uk Kim, Hyun Cheol Kim, and Soontae Kim

Atmosphere 2017, 8(10), 187; https://doi.org/10.3390/atmos8100187

Evaluation of improved land use and canopy representation in BEIS v3.61 with biogenic VOC measurements in California
Jesse O. Bash, Kirk R. Baker, and Melinda R. Beaver

Geosci. Model Dev., 9, 2191-2207, 2016

Improved MEGAN predictions of biogenic isoprene in the contiguous United States
Peng Wang, Gunnar Schade, Mark Estes, Qi Ying

Atmospheric Environment Volume 148, January 2017, Pages 337-351
Biogenic emission inventories were developed for May through September 2012 using the Model of Emissions of Gases and Aerosols from Nature (MEGAN) 2.10 and Biogenic Emission Inventory System (BEIS) 3.61 for Texas State Implementation Plan photochemical modeling. Results from both models were evaluated for isoprene and ozone performance. June 2012 results are shown here as a representative month.

**MODEL CONFIGURATIONS**

MEGAN 2.10 and BEIS 3.61 were run for May through September 2012 using the same WRF 3.7.1 configuration. The Comprehensive Air Quality Model with extensions (CAMx) was run with each biogenic emission inventory.

MEGAN was configured with the latest emission factors and plant functional type (PFT) data, developed in 2015 (AQRF, 2015). The 2015 aircraft-based isoprene emission factor is approximately 50% of the default 2011 factor. Leaf Area Index data was created from the MODIS product with urban corrections (Ying et al, 2015).

BEIS was configured with EPA’s Modeling Platform 2011b_v3, which used the BEIL4 land-use, CB05 speciation, and default emission factors.

**EMISSIONS**

MEGAN consistently produced more isoprene emissions than BEIS in Texas during 2012. MEGAN generated emissions earlier and later in the day than BEIS, when low planetary boundary layer heights (PBL) appeared to exacerbate the difference in emission rates and concentrations.

**ISOPRENE PERFORMANCE**

23 automatic Gas Chromatographs (auto-GCs) operated in 2012 that measured hourly isoprene and other volatile organic compounds. All auto-GCs were located in urban areas and/or near anthropogenic emission sources; a direct comparison to observed biogenic isoprene wasn’t possible.

**OZONE PERFORMANCE**

Over 100 Texas ozone monitors operating in 2012 were used to evaluate CAMx photochemical model output. While there was a large mean difference in isoprene concentrations between MEGAN and BEIS, mean ozone concentrations were similar as shown in the bias maps below.

**CONCLUSIONS**

MEGAN consistently over-predicted isoprene concentrations throughout Texas in 2012, with higher emission rates in the morning and evening. BEIS produced isoprene concentrations similar to observed and CAMx ozone results showed better agreement on the important high ozone days.
MEGAN3 NO emission factor low by 10000
BEIS3 Shake-Out: Missing Lakes

BELD4 Original

WRF–MCIP Output

WRF = Weather Research and Forecasting model
MCIP = Meteorology–Chemistry Interface Processor
Biogenic Model Comparison

EMIS_DENSITY, MEGAN v3 VS BEIS3, ISOP, 0701-0731

BEIS3 (Tons/km²)
N: 3198, MIN: 0.00, MAX: 3.12, AVG: 0.58
(MEGAN v3)-(BEIS3) (Tons/km²)
N: 3198, MIN: 0.02, MAX: 3.78, AVG: 0.74
{(MEGAN v3)-(BEIS3)}/(BEIS3)*100 (%)
MEGAN3 vs. BEIS3 emissions: July Isoprene

EMIS_DENSITY, MEGAN v3 VS BEIS3, ISOP, 0701-0731

BEIS3 (Tons/km²)

N: 3198, MIN: 0.00, MAX: 3.12, AVG: 0.58

(MEGAN v3)-(BEIS3) (Tons/km²)

N: 3198, MIN: -1.46, MAX: 2.59, AVG: 0.16

MEGAN v3 (Tons/km²)

N: 3198, MIN: 0.02, MAX: 3.78, AVG: 0.74

{(MEGAN v3)-(BEIS3)}/(BEIS3)*100 (%)
MEGAN vs. BEIS3 emissions: July Nitric Oxide

![Comparison of EMIS DENSITY between MEGAN v3 and BEIS3 for NO emissions between 0701-0731. The maps show the distribution of emissions with color gradients indicating different concentrations.](image)
Model Performance Evaluation: 2016 Ozone Observations
Model Performance Evaluation:
2016 Isoprene Flux Observations

Flux data courtesy of Dylan Millet, Professor of Atmospheric Chemistry, Dept of Soil, Water & Climate, Univ of Minnesota
Model Performance Evaluation: 2016 Isoprene Flux Observations
Model Performance Evaluation: 2016 Isoprene Flux Observations

20160728 ISOP

- MEGAN
- BEIS
- PROPHET

Tons

Hour
Use our data!

- 12km EPAUS2 domain output for both models on Intermountain West Data Warehouse (IMDW)
  - January 1 – December 31, 2016
  - Carbon Bond 6 chemical mechanism
  - BEIS 3.61 documentation
  - MEGAN 3.0 documentation

- New York Department of Environmental Conservation 11:15 AM Presentation
  - The 2016 National Emissions Inventory Collaborative: Modeling with the Beta Platform
2016 version 1
- Environment Canada BELD4 landuse implementation for BEIS3
- Expected release date: August 2019

Model Performance Evaluation
- Looking for air quality model evaluation results (one run with BEIS3 and one with MEGAN3 for comparison)
- Southeast Atmosphere Study (SAS) 2013 evaluation
  - NOAA P–3 and C–130 aircraft flights
    - Isoprene and monoterpene flux
  - MEGAN3 2013 complete
  - BEIS3 2013 to come

2013 Flight Tracks
https://www.esrl.noaa.gov/csd/groups/csd7/measurements/2013senex/P3/flighttrack
Biogenics Workgroup: Join Us

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Thanks to the workgroup members for their sustained contributions over the past year and a half!